Article

Vaccine usage in western Canadian cow-calf herds

Cheryl L. Waldner, Sarah Parker, John R. Campbell

Abstract — The aims of this study were to describe when and how vaccines are administered during the production cycle in cow-calf herds in western Canada, as well as the factors that influence vaccine usage as reported by producers. The most commonly used vaccines were bovine viral diarrhea virus/infectious bovine rhinotracheitis (BVDV/IBR) in adult animals and clostridial vaccines in calves. While there has been improvement in usage of reproductive and respiratory viral vaccines since previous studies, there are still several areas in which uptake could be improved. Only 72% of herd owners vaccinated their bulls for at least 1 disease. Not all producers are vaccinating their calves for clostridial diseases, and 15% of producers did not vaccinate their calves for respiratory disease before weaning. One goal of increasing vaccine use is to obtain better infection prevention and control and decrease antimicrobial use in cow-calf herds. Two areas in which antimicrobials are commonly used, but vaccine uptake is limited, are foot rot in adult cows and diarrhea in calves.

Résumé — Usage des vaccins dans les troupeaux d'élevage-naissage de l'Ouest canadien. Les buts de cette étude étaient de décrire quand et comment les vaccins étaient administrés durant le cycle de production dans les troupeaux d'élevage-naissage de l'Ouest canadien ainsi que les facteurs influençant l'usage des vaccins signalés par les producteurs. Les vaccins les plus communément utilisés étaient le BVDV/IBR chez les animaux adultes et les vaccins clostridiens chez les veaux. Même s'il s'est produit une amélioration de l'usage des vaccins pour la reproduction et les virus respiratoires par rapport aux études antérieures, il y a toujours plusieurs domaines où la prise du vaccin pourrait être améliorée. Seulement 72 % des propriétaires de troupeaux vaccinaient leurs taureaux pour au moins 1 maladie. Ce ne sont pas tous les producteurs qui vaccinent leurs veaux pour les maladies clostridiennes et 15 % des producteurs ne vaccinent pas leurs veaux pour la maladie respiratoire avant le sevrage. Un but de l'augmentation de l'usage des vaccins consiste à mieux prévenir les infections et à contrôler et diminuer l'usage des antimicrobiens chez les troupeaux d'élevage-naissage. Deux domaines où les antimicrobiens sont couramment utilisés, mais la prise du vaccin est limitée, sont le piétin chez les vaches adultes et la diarrhée des veaux.

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Introduction

The importance of infection prevention and control to minimize the use of antimicrobials and antimicrobial resistance has recently been highlighted as part of the Pan-Canadian Framework for Action on "Tackling Antimicrobial Resistance and Use" (1). The most common reasons for antimicrobial use in cow-calf operations are respiratory disease and diarrhea in calves before weaning, respiratory disease in calves after weaning, and lameness in cows and bulls (2). Vaccination can be an effective tool for preventing the introduction and spread of many of these infectious diseases (3–8).

A recent survey of 148 veterinarians from the United States and Canada who provided service to cow-calf clients summarized vaccine recommendations for calves at branding, weaning, post-weaning and annual vaccinations for breeding females (9). However, there is little current information on what vaccines are being used in cow-calf herds and at what point they are administered during the production cycle.

In a 2002 study of 200 western Canadian herds, 37.5% of herds used modified-live bovine viral diarrhea virus (BVDV) and infectious bovine rhinotracheitis (IBR) vaccines and 41.5% used inactivated vaccines (10). This same cohort of herds reported

Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5B4.

Address all correspondence to Dr. Cheryl Waldner; e-mail: cheryl.waldner@usask.ca

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using vaccines for calf diarrhea in cows in 50% of herds and in heifers in 53% of herds (11). Furthermore, 28% of herd owners used a modified-live vaccine against BVDV and IBR virus in the calves before the herds were moved to summer pasture in the spring of 2002; 3% used an inactivated vaccine (12).

In 2007, the National Animal Health Monitoring System (NAHMS) in the United States collected data on vaccine use in calves, cows, and bulls (13). The most commonly vaccinated group was calves before weaning (62%) with the most common vaccines being for clostridial diseases (58%), IBR (30%), and BVDV (33%). In cows, the most common target of vaccination was leptospirosis (32%) followed by BVDV (28%) and IBR (25%), and in bulls it was BVDV (24%) followed by leptospirosis (21%).

The next available Canadian data resulted from a 2010 survey of 310 producers (14). This study included information on vaccine use in calves before summer pasture and the use of calf scours and clostridial vaccines in cows and heifers. The most commonly used vaccines in calves were for clostridial diseases (85%), BVDV and IBR (56%), and "other" respiratory pathogens (32%). Producers were more likely to vaccinate their cows or heifers for clostridial diseases (57%) than for scours (*E. coli,* rotavirus, or coronavirus) (47%).

There have been no data published on vaccine use since 2010 (14) for the Canadian cow-calf industry and most of the data from 2010 and earlier is limited to yes or no questions for specific vaccines. Earlier studies did not look at the specific timing of vaccination and did not consider vaccines in calves after weaning or in bulls. Current information is needed by veterinarians and the beef industry to identify opportunities for improvements in infection prevention and control and to provide benchmarks to motivate change in producers who have not yet adopted common vaccination practices. The primary objective of this study was to describe which vaccines are administered and at what time during the production cycle they are used in cow-calf herds in western Canada. The second objective was to describe the factors which producers report influence vaccine usage and what sources of information producers rely on for vaccines.

Materials and methods

Survey design

A paper-based survey was developed to assess vaccine usage. Changes were made to the survey in response to comments from a test group of 6 producers and veterinarians. Producers were provided with a vaccine reference handbook that included commercial product names and color photographs of product packaging for vaccines approved for use in cattle in Canada during 2016. The handbook was reviewed to check completeness and accuracy.

Survey content

The survey consisted of 2 sections. The first section measured vaccine use between January 1, 2016 and December 31, 2016 in 4 production groups: bulls, cows, unweaned calves, and weaned calves. Questions for each group were presented in separate tables. The first set of questions for each production group was whether vaccines were administered to any animals from the group for a list of common indications. If vaccine use was reported for the condition, the next questions were which vaccines were used, when each vaccine was used relative to various management activities, and the months during which the first and second doses were given. The second section of the survey asked about diseases of most concern when choosing vaccines, producer motivations for vaccine use, factors influencing vaccine choices, and primary sources of information on vaccines. Approval for the study was provided by the University of Saskatchewan Behavioural Research Ethics Board (#14-07) and a copy of the survey is available by e-mail request.

Participant recruitment and survey distribution

Cow-calf producers from western Canada participating in a cattle health and productivity surveillance network established in 2014 were eligible to receive this survey. National census data (15) had been used to target selection of cow-calf herds for the network within each province with the goal of matching reported distribution of herd sizes and herd density.

Veterinarians were asked to identify potential participants from their beef cattle clientele who pregnancy-checked and maintained basic calving and production records. Producers returning the consent form and initial survey with baseline information were included in the network.

In February 2017, the 10th network survey requesting vaccine information was distributed to the 106 participants who had responded to the network within the previous 12 mo. First reminders were sent in March 2017 and further reminders were sent each time additional material was sent to participants. Ninety-three responses were returned between March 2017 and February 2018 for a return rate of 88%. Producers were provided with a small honorarium for surveys completed each year.

Data management and statistical analysis

Responses were entered into a commercial spreadsheet program and checked for accuracy. Data from the vaccine survey were merged with herd attribute information collected at the time of enrollment using a database program. Product names as reported by producers were manually linked to a list of vaccines licensed for use in Canada as reported in the Compendium of Veterinary Products (16) to determine each vaccine's target components. Additional details, including information on specific clostridial vaccine components, were obtained directly from individual product packaging materials.

The study population was described, and vaccine use and other survey responses were summarized across herds using appropriate statistics.

Results

Study population

Of the 93 surveys that were returned, 79 were from herds first enrolled in 2014, 4 from herds first enrolled in 2015, and 10 from 2016. Forty-six surveys were returned from Alberta, 29 from Saskatchewan, 17 from Manitoba, and 1 from British Columbia. The median herd size at the start of calving in 2016 was 230 cows and heifers [interquartile range (IQR): 163 to 355]. Thirty-seven percent of respondents (34/93) had $>$ 300 cows and heifers.

Twenty-six percent (24/93) of survey participants reported that a portion of their herd was managed as purebred. Calving

Table 1. Summary of the vaccines used and frequency of use in bulls, cows, and replacement heifers from January 1 to December 31, 2016 in 93 cow-calf herds reported as the proportion of herds (and number of herds).

	Bulls		Cows		Replacement heifers	
Vaccine components	Vaccinated at least once	Vaccinated twice	Vaccinated at least once	Vaccinated twice	Vaccinated at least once	Vaccinated ≥ 2 times
Bovine viral diarrhea virus (BVDV) type 1	**0.55 (51)**	0.02 (2)	**0.91 (85)**	0.04 (4)	**0.96 (89)**	0.26 (24)
Bovine viral diarrhea virus (BVDV) type 2	**0.55 (51)**	0.02 (2)	**0.91 (85)**	0.04 (4)	**0.96 (89)**	0.26 (24)
Infectious bovine rhinotracheitis (IBR)	**0.55 (51)**	0.02 (2)	**0.91 (85)**	0.04 (4)	**0.96 (89)**	0.26 (24)
Parainfluenza virus (PI3)	0.53 (49)	0.02 (2)	0.86 (80)	0.04 (4)	0.91 (85)	0.25 (23)
Bovine respiratory syncytial virus (BRSV)	0.53 (49)	0.02 (2)	0.86 (80)	0.04 (4)	0.91 (85)	0.25 (23)
Campylobacter fetus	0.12 (11)	0 (0)	0.16 (15)	0.01 (1)	0.18 (17)	0.04 (4)
Leptospira borgpetersenii serovar: hardjo-bovis	0.02 (2)	0 (0)	0.02 (2)	0 (0)	0.02 (2)	0 (0)
L. interrogans serovar: hardjo	0.14 (13)	0 (0)	0.18 (17)	0.01 (1)	0.19 (18)	0.04 (4)
Leptospira pomona	0.14 (13)	0 (0)	0.19 (18)	0.01 (1)	0.19 (18)	0.04 (4)
Leptospira spp.	0.14 (13)	0 (0)	0.19 (18)	0.01 (1)	0.19 (18)	0.04 (4)
Histophilus somni	0.14 (13)	0.02 (2)	0.22 (20)	0.03 (3)	0.30 (28)	0.10 (9)
Mannheimia haemolytica	0.02 (2)	0.01 (1)	0.04 (4)	0 (0)	0.05 (5)	0.01 (1)
Pasteurella multocida	0.01 (1)	0 (0)	0.02 (2)	0 (0)	0.02 (2)	0 (0)
Coronavirus	0 (0)	0 (0)	0.52 (48)	0.08 (7)	**0.54 (50)**	**0.46 (43)**
Rotavirus	0 (0)	0 (0)	0.52 (48)	0.08 (7)	**0.54 (50)**	**0.46 (43)**
Escherichia coli	0 (0)	0 (0)	0.43 (40)	0.06 (6)	0.48 (45)	0.25 (23)
Clostridium chauvoei, Cl. septicum, Cl. novyi, Cl. perfringens types C and D	0.32 (30)	0.02 (2)	0.45 (42)	0.03 (3)	0.69 (64)	0.06 (6)
Clostridium sordellii	0.28 (26)	0.02 (2)	0.40 (37)	0.03 (3)	0.63 (59)	0.05 (5)
Clostridium perfringens type B	0.04 (4)	0 (0)	0.05 (5)	0 (0)	0.06 (6)	0 (0)
Clostridium haemolyticum	0.22 (20)	0.01 (1)	0.33 (31)	0.01 (1)	0.45 (42)	0.02 (2)
Clostridium tetani	0.13 (12)	0.01 (1)	0.15 (14)	0.01 (1)	0.19 (18)	0.01 (1)
Anthrax	0.02 (2)	0 (0)	0.02 (2)	0 (0)	0.02 (2)	0 (0)
Fusobacterium necrophorum	0.39 (36)	0.08 (7)	0 (0)	0 (0)	0.02 (2)	0.01 (1)
Moraxella bovis	0.06 (6)	0 (0)	0 (0)	0 (0)	0.02 (2)	0 (0)
Papillomavirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total herds reporting use of any vaccine	**0.72 (67)**	**0.12 (11)**	**0.97 (90)**	**0.14 (13)**	**0.97 (90)**	**0.58 (54)**

Vaccines used most frequently are shown in bold.

began between December 2015 and May 2016, and 42% (39/93) of herds started calving before March 1. In the Fall of 2016, 39% (36/93) of the herds weaned before November 2016, but calves were weaned from August 2016 through January 2017.

Vaccine use in bulls, cows, and replacement heifers

While almost all producers (97%) vaccinated their cows with at least 1 product, only 72% of producers vaccinated bulls. The most common targets of vaccination for both bulls and cows were BVDV and IBR (Table 1). The next most commonly reported targets of vaccination were other respiratory viruses for both bulls and cows, followed by foot rot in bulls and calf diarrhea in cows. Very few herds vaccinated their bulls or cows more than once with a single product or boosted vaccines during 2016 (Table 2). The most common time for vaccinating bulls and cows was before breeding during the period from April through June (Table 3). Most producers reported using modified live (ML) vaccines for BVDV and other respiratory viruses. One herd used a ML intranasal (IN) vaccine in bulls for *Mannheimia* and *Pasteurella.* None of the herds reported use of IN vaccines in cows. Only 1 herd reported using a monovalent bacterin for *Campylobacter fetus* spp. *venerealis* in cows and another herd reported using it in bulls. All other herds vaccinating for bovine genital campylobacteriosis did so as part of a combined product with ML viral vaccines. All products containing *Leptospira* antigens were combined with ML viral vaccines.

Clostridial vaccines were the third most commonly reported vaccines in replacement heifers after reproductive and respiratory viruses and were used slightly more frequently than scours vaccines (Table 1). Most herd owners reported a second or booster dose of calf scours vaccination for replacement heifers. In contrast to cows, replacement heifers were as likely to be administered prebreeding vaccines in the period from January to March as in the period from April to June. No producers reported use of IN vaccines in replacement heifers.

Vaccine use in calves

While most producers used at least 1 vaccine in their calves before weaning, fewer producers used vaccines in their calves after weaning (Table 2). However, only 41% (38/93) of participants reported backgrounding calves, 8% (7/93) having stockers, and 11% (10/93) having a feedlot. Of the herds that reported backgrounding their calves 63% (24/38) used vaccines at or after weaning and of those who had stocker calves or a feedlot, 71% (12/17) used vaccines at or after weaning.

The most common targets of vaccination were clostridial diseases in calves both before and after weaning, followed by respiratory viruses (Table 2). Before weaning, boosting was reported more frequently for respiratory virus vaccines than for other vaccine types.

Preweaned calves were most likely to be vaccinated before summer pasture turnout in the period from April to June (Table 3). Sixteen herds (17%) reported IN use of vaccines in

Table 2. Summary of the vaccines used and frequency of use in unweaned and weaned calves from January 1 to December 31, 2016 in 93 cow-calf herds reported as the proportion of herds (and number of herds).

	Unweaned calves		Weaned calves	
Vaccine components	Vaccinated at least once	Vaccinated ≥ 2 times	Vaccinated at least once	Vaccinated ≥ 2 times
Bovine viral diarrhea virus (BVDV) type 1	0.82 (76)	0.26 (24)	0.48 (45)	0.03 (3)
Bovine viral diarrhea virus (BVDV) type 2	0.82 (76)	0.26 (24)	0.48 (45)	0.03 (3)
Infectious bovine rhinotracheitis (IBR)	0.85 (79)	0.34 (32)	0.49 (46)	0.03 (3)
Parainfluenza virus (PI3)	0.85 (79)	0.34 (32)	0.49 (46)	0.03 (3)
Bovine respiratory syncytial virus (BRSV)	0.85 (79)	0.34 (32)	0.49 (46)	0.03 (3)
Campylobacter fetus	0.02 (2)	0 (0)	0.03 (3)	0 (0)
Leptospira borgpetersenii serovar: hardjo-bovis	0.02 (2)	0 (0)	0.01 (1)	0 (0)
L. interrogans serovar: hardjo	0.03 (3)	0 (0)	0.03 (3)	0 (0)
Leptospira pomona	0.03 (3)	0 (0)	0.03 (3)	0 (0)
Leptospira spp.	0.03 (3)	0 (0)	0.03 (3)	0 (0)
Histophilus somni	0.45 (42)	0.11 (10)	0.28 (26)	0.01 (1)
Mannheimia haemolytica	0.67 (62)	0.19 (18)	0.35 (33)	0.01 (1)
Pasteurella multocida	0.17 (16)	0.03 (3)	0.12 (11)	0 (0)
Coronavirus	0.04 (4)	0 (0)	0 (0)	0 (0)
Rotavirus	0.04 (4)	0 (0)	0 (0)	0 (0)
Escherichia coli	0 (0)	0 (0)	0 (0)	0 (0)
Clostridium chauvoei, Cl. septicum, Cl. novyi, Cl. perfringens types C and D	**0.97 (90)**	0.32 (30)	**0.56 (52)**	0.01 (1)
Clostridium sordellii	0.91 (85)	0.31 (29)	0.52 (48)	0.01 (1)
Clostridium perfringens type B	0.06 (6)	0.01 (1)	0.04 (4)	0 (0)
Clostridium haemolyticum	0.46 (43)	0.14 (13)	0.27 (25)	0.01 (1)
Clostridium tetani	0.15 (14)	0.01 (1)	0.09 (8)	0 (0)
Anthrax	0.01 (1)	0 (0)	0 (0)	0 (0)
Fusobacterium necrophorum	0 (0)	0 (0)	0.01 (1)	0.01 (1)
Moraxella bovis	0.01 (1)	0 (0)	0 (0)	0 (0)
Papillomavirus	0 (0)	0 (0)	0 (0)	0 (0)
Total herds reporting use of any vaccine	**0.96 (89)**	**0.43 (40)**	**0.57 (53)**	**0.04 (4)**

Vaccine used most frequently is shown in bold.

calves before weaning: 14 (15%) with modified-live viral vaccines (IBR, PI3, BRSV) (11 before turnout to summer pasture) and 5 (5%) with modified-live *Mannheimia* and *Pasteurella* (4 before turnout to summer pasture).

Twelve herds (13%) reported using vaccines at birth. Eight herds (9%) reported using IN vaccines for respiratory disease at birth (7 for viruses and 4 for bacteria), 3 herds (3%) reported using oral calf scours vaccines, and 3 herds (3%) reported using injectable clostridial vaccines at birth.

Weaned calves were most likely to have been vaccinated at weaning compared with after and in the period October to December (Table 3). Only 1 producer reported using an IN vaccine for respiratory virus in calves at weaning.

Vaccination data were also summarized across all calves considering the complete period from birth through and after weaning. More than half of producers administered at least 2 doses of vaccine for clostridial diseases, BVDV, and respiratory viruses to calves (Table 4). More than half of producers who used *Histophilus* and *Mannheimia* vaccines in calves later boosted the initial dose either before or after weaning.

Only 2 herds provided 2 doses of IN vaccine for respiratory viruses: 1 herd administered both doses before weaning and 1 herd administered 1 dose before and 1 at weaning.

Motivation for vaccine choices and sources of vaccine information

Producers were most likely to rank reproductive and viral respiratory diseases in their list of top 3 concerns motivating vaccination in bulls, cows, and replacement heifers (Table 5). Similarly, for calves both before and after weaning, producers ranked viral and bacterial respiratory diseases in their list of top 3 concerns motivating vaccination (Table 5). Producers were most likely to report using respiratory vaccines because they had a problem in the past and wanted to prevent it from happening again (Table 6). In contrast, they were most likely to report using vaccines for reproductive diseases because they had not had a problem and were trying to prevent it (Table 6).

The importance of the disease in the herd and economic benefits of the vaccines were most often ranked in the top 3 reasons for deciding which vaccines to use, followed by the potential of the vaccine to minimize treatment rates and antimicrobial resistance (Table 7). Cost and convenience factors were reported less often. Veterinarians were the most important sources of vaccine information reported by this group of herd owners followed by friends and neighbors and producer publications (Table 8). Websites and social media were ranked as important sources of information by a much smaller proportion of participants.

Discussion

This study provides the first report detailing the timing and frequency of vaccine use across all production groups, including herd bulls, in western Canadian cow-calf herds. While most cow-calf producers herein reported using at least some vaccines to manage infectious disease in their herds, opportunities were identified in which uptake of effective vaccine programs can be improved. We also identified areas in which more research is

Table 3. Summary of timing of reported vaccine use in bulls, cows, unweaned and weaned calves for any vaccine and the most commonly used types of vaccine in 93 cow-calf herds. Reported as the proportion of herds (and number of herds) with at least one activity within the reported category.

	Any vaccine	BVDV	Other reproductive pathogens	Any respiratory pathogens	*Clostridia* spp.	Calf diarrhea scours)	Foot rot
Bulls							
Vaccine timing							
• Before breeding	**0.67 (62)**	0.48 (45)	0.13 (12)	0.48 (45)	0.29 (27)	0 (0)	0.39 (36)
• After breeding	0.08 (7)	0.08 (7)	0.02 (2)	0.08 (7)	0.04 (4)	0 (0)	0 (0)
Season of vaccination							
• January to March	0.16 (15)	0.13 (12)	0.02 (2)	0.13 (12)	0.09 (8)	0 (0)	0.06 (6)
• April to June	**0.45 (42)**	0.30 (28)	0.09 (8)	0.30 (28)	0.14 (13)	0 (0)	0.28 (26)
• July to September	0.08 (7)	0.03 (3)	0.01 (1)	0.03 (3)	0.03 (3)	0 (0)	0.05 (5)
• October to December							
Use of modified live vaccine	0.55 (51)	0.55 (51)	0.14 (13)	0.53 (49)	n/a	0 (0)	n/a
Use of killed or inactivated vaccine	0.60 (56)	0 (0)	0.15 (14)	0.01 (1)	0.32 (30)	0 (0)	0.39 (36)
Cows							
Vaccine timing							
• Before breeding	**0.58 (54)**	0.57 (53)	0.11 (10)	0.53 (49)	0.18 (17)	0.01 (1)	0 (0)
• Pregnancy testing	0.33 (31)	0.22 (20)	0.06 (6)	0.22 (20)	0.17 (16)	0.10 (9)	0 (0)
• Before calving	0.47 (44)	0.15 (14)	0.04 (4)	0.15 (14)	0.13 (12)	0.44 (41)	0 (0)
Season of vaccination							
• January to March	0.41 (38)	0.16 (15)	0.02 (2)	0.15 (14)	0.09 (8)	0.34 (32)	0 (0)
• April to June	**0.51 (47)**	0.48 (45)	0.11 (10)	0.44 (41)	0.16 (15)	0.03 (3)	0 (0)
• July to September	0.01 (1)	0.01 (1)	0.01 (1)	0.01 (1)	0.01 (1)	0 (0)	0 (0)
• October to December	0.39 (36)	0.25 (23)	0.08 (7)	0.26 (24)	0.18 (17)	0.14 (13)	0 (0)
Use of modified live vaccine	0.86 (80)	0.84 (78)	0.18 (17)	0.81 (75)	n/a	0 (0)	n/a
Use of killed or inactivated vaccine	0.78 (73)	0.09 (8)	0.2 (19)	0.09 (8)	0.45 (42)	0.52 (48)	0 (0)
Replacement heifers							
Vaccine timing							
• Before breeding	**0.82 (76)**	0.78 (73)	0.18 (17)	0.76 (71)	0.49 (46)	0.01 (1)	0.02 (2)
• Pregnancy testing	0.40 (37)	0.14 (13)	0.02 (2)	0.17 (16)	0.14 (13)	0.26 (24)	0 (0)
• Before calving	0.54 (50)	0.17 (16)	0.02 (2)	0.17 (16)	0.11 (10)	0.51 (47)	0 (0)
Season of vaccination							
• January to March	**0.58 (54)**	0.27 (25)	0.06 (6)	0.26 (24)	0.19 (18)	0.41 (38)	0 (0)
• April to June	0.56 (52)	0.51 (47)	0.11 (10)	0.49 (46)	0.32 (30)	0.04 (4)	0.02 (2)
• July to September	0.04 (4)	0.02 (2)	0.01 (1)	0.02 (2)	0.01 (1)	0.02 (2)	0 (0)
• October to December	0.46 (43)	0.24 (22)	0.04 (4)	0.26 (24)	0.16 (15)	0.31 (29)	0 (0)
Use of modified live vaccine	0.91 (85)	0.89 (83)	0.19 (18)	0.87 (81)	n/a	0 (0)	n/a
Use of killed or inactivated vaccine	0.91 (85)	0.06 (6)	0.22 (20)	0.08 (7)	0.69 (64)	0.54 (50)	0.02 (2)
Calves before weaning							
Vaccine timing							
• Before summer pasture turnout	**0.69 (64)**	0.46 (43)	0.03 (3)	0.55 (51)	0.66 (61)	0.04 (4)	0 (0)
• At summer pasture turnout	0.28 (26)	0.24 (22)	0 (0)	0.26 (24)	0.27 (25)	0 (0)	0 (0)
• After summer pasture turnout	0.32 (30)	0.27 (25)	0 (0)	0.29 (27)	0.30 (28)	0 (0)	0 (0)
• Other							
Season of vaccination							
• January to March	0.17 (16)	0.03 (3)	0 (0)	0.15 (14)	0.05 (5)	0.04 (4)	0 (0)
• April to June	**0.85 (79)**	0.66 (61)	0.03 (3)	0.72 (67)	0.85 (79)	0 (0)	0 (0)
• July to September	0.08 (7)	0.06 (6)	0 (0)	0.08 (7)	0.08 (7)	0 (0)	0 (0)
• October to December	0.28 (26)	0.24 (22)	0 (0)	0.25 (23)	0.26 (24)	0 (0)	0 (0)
Use of modified live vaccine	0.85 (79)	0.81 (75)	0.03 (3)	0.85 (79)	n/a	0.04 (4)	n/a
Use of killed or inactivated vaccine	0.96 (89)	0 (0)	0.03 (3)	0.52 (48)	0.96 (89)	0 (0)	0 (0)
Calves after weaning							
Vaccine timing							
• At weaning	**0.37 (34)**	0.31 (29)	0.01 (1)	0.35 (33)	0.37 (34)	0 (0)	0 (0)
• After weaning	0.22 (20)	0.17 (16)	0.02 (2)	0.18 (17)	0.19 (18)	0 (0)	0.01 (1)
Season of vaccination							
• January to March	0.05 (5)	0.04 (4)	0.01 (1)	0.04 (4)	0.04 (4)	0 (0)	0.01 (1)
• April to June	0.01 (1)	0.01 (1)	0 (0)	0.01 (1)	0.01 (1)	0 (0)	0 (0)
• July to September	0.02 (2)	0.02 (2)	0 (0)	0.02 (2)	0.02 (2)	0 (0)	0 (0)
• October to December	**0.51 (47)**	0.43 (40)	0.02 (2)	0.47 (44)	0.47 (44)	0 (0)	0 (0)
Use of modified live vaccine	0.49 (46)	0.48 (45)	0.03 (3)	0.49 (46)	n/a	0 (0)	n/a
Use of killed or inactivated vaccine	0.57 (53)	0 (0)	0.03 (3)	0.24 (22)	0.56 (52)	0 (0)	0.01 (1)

[a] Total does not reflect a sum of the column as some herds used more than one product or vaccinated more than once within a year.
Vaccines used most frequently are shown in bold. n/a — not applicable.

Table 4. Summary of most common vaccines used and frequency of use in all calves (before and after weaning) from January 1 to December 31, 2016 in 93 cow-calf herds reported as the proportion of herds (and number of herds).

	All calves (before or after weaning)	
Vaccine components	Vaccinated at least once	Vaccinated ≥ 2 times
Bovine viral diarrhea virus (BVDV) type 1 or 2	0.92 (86/93)	0.63 (59/93)
Infectious bovine rhinotracheitis (IBR) and Parainfluenza virus (PI3) and Bovine respiratory syncytial virus (BRSV)	0.95 (88/93)	0.68 (63/93)
Histophilus somni	0.53 (49/93)	0.31 (29/93)
Mannheimia haemolytica	0.74 (69/93)	0.43 (40/93)
Pasteurella multocida	0.22 (20/93)	0.09 (8/93)
Clostridium chauvoei, Cl. septicum, Cl. novyi, Cl. perfringens types C and D	0.99 (92/93)	0.81 (75/93)

needed to examine the cost-effectiveness of existing vaccines or to develop improved and affordable vaccines to help enhance infection prevention and reduce the need for antimicrobials.

The most common vaccines used in the adult breeding herd were for BVDV and IBR and modified live products were the most frequently used vaccine type. In most cases, these antigens were in combination with BRSV and PI3 virus. This finding was not surprising given that veterinarians were named as the most important source of information regarding vaccines and modified live BVDV and IBR vaccines are only available from veterinarians. Most producers reported using these vaccines to prevent reproductive disease because they had not had a problem in the past and were trying to avoid disease incursion. The use of these vaccines has increased in the last 15 y as the proportion of herds in which cows were vaccinated for BVDV and IBR was almost double that from our 2002 study (10). The herds for the 2002 study were recruited with veterinary clinics using a similar approach and represent the same general geographic area as the present study. While more recent published data were not identified for western Canada, our findings also indicated much higher rates of vaccine uptake than reported in the 2007 NAHMS study from the United States (13).

The decision by almost all producers to vaccinate cows and replacement heifers for BVDV and IBR was not surprising given that economic benefits were ranked highly as a determinant of vaccine choice. A recent meta-analysis identified an average 85% decrease in fetal infection, 45% decrease in abortions, and 5% increase in pregnancy rates across published trials associated with vaccination for BVDV (4) and an average 60% decrease in abortions in cattle vaccinated for IBR (3). We have also observed higher pregnancy rates and lower abortion losses in vaccinated beef cows on community pastures in western Canada compared to animals exposed to community pastures that were not vaccinated (10,17).

Many of the combined BVDV and IBR products used in adult cattle also protect against other viral respiratory disease such as PI3 and bovine respiratory syncytial virus (BRSV), with only a small percentage of producers choosing products that did not include the BRSV antigens. Very few producers, however, reported using vaccines for bacterial respiratory diseases. Respiratory disease was the third most common reason for treating bulls with antimicrobials in these herds (2) but was a less frequent reason for treatment in adult cows. At least some producers recognized the dual benefits of the combination viral vaccines as some reported combined BVDV, IBR, PI3, and BRSV vaccines under both reproductive and respiratory disease for adult animals. However, because of the way the questions were asked it was not possible to conclude precisely to what extent respiratory disease was a primary motivator for viral vaccine use in adult animals.

The most common targets of vaccination in calves before weaning were clostridial diseases. This was also consistent with the finding that economic benefits were an important factor in choosing vaccines. Clostridial vaccines are effective in preventing disease following natural exposure (18). However, while the percentage of producers who vaccinated was higher than in 2010 (14), there were 3 producers who did not vaccinate their calves at all before weaning and 1 who did not use clostridial vaccines either before or after weaning. More than 80% of producers provided a second dose either before or at weaning, but the precision of the date information provided was not sufficient in most cases to determine if the second dose was given approximately 6 wk after the first in accordance with label recommendations. The second dose was provided before weaning in only 32% of herds. Calves vaccinated for clostridial diseases under 3 mo of age should be revaccinated after maternal antibodies have dissipated after 4 to 6 mo. While many calves are first vaccinated when less than 3 mo old, a few herds were routinely vaccinated with inactivated clostridial vaccines at birth. This is too early to expect protective immunity in the presence of maternal antibodies (6,19).

The second most common target of vaccination in pre-weaning calves (85% IBR, PI3, BRSV, 82% BVDV, and 67% *Mannheimia haemolytica*) and the most common reason for antimicrobial use (AMU) in weaned calves was respiratory disease. Most herd owners reported using vaccines for respiratory disease because they had a problem in the past and were attempting to prevent the problem from happening again. While there is evidence that respiratory vaccines can be effective, there is more work needed to determine the optimum vaccine protocol for calves before weaning (5,7,20). The percentage of herds using viral vaccines for BVDV and IBR in calves at or before summer pasture was slightly higher in the present study (70%) than that reported in 2010 (56%) (14), and higher than in 2002 (31%) (10).

One of the biggest changes from the results of the 2010 survey was the increase in the use of IN respiratory vaccines at birth. Several intranasal vaccines for cattle have been added to the market in Canada in the past few years, and therefore, this result was not unexpected. In the 2010 survey, only 1 herd reported using an IN vaccine for IBR and PI3 at birth; whereas, in the present study 8 herds or 9% reported IN vaccines at birth with 17% in total reporting IN vaccines for respiratory disease before weaning. Most producers choosing the IN route were using viral vaccines; however, a smaller number of producers

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Table 5. Summary of level of concern motivating vaccination against different pathogen types as reported by 93 cow-calf herd owners for different classes of cattle.

	% of herds ranking each disease in top 3 reasons for concern (number)				
	Bulls	Mature cows	Replacement heifers	Calves before weaning	Calves after weaning
Anthrax	0.01 (1)	0.03 (3)	0.03 (3)	0 (0)	0.01 (1)
Calf diarrhea (scours)	0.01 (1)	0.31 (29)	0.26 (24)	0.19 (18)	0 (0)
Clostridial diseases	0.24 (22)	0.29 (27)	0.40 (37)	0.55 (51)	0.58 (54)
Foot rot	0.31 (29)	0.01 (1)	0.01 (1)	0.01 (1)	0.04 (4)
Pinkeye	0.08 (7)	0.02 (2)	0.01 (1)	0 (0)	0.01 (1)
Reproductive disease	**0.42 (39)**	**0.84 (78)**	**0.82 (76)**	0.29 (27)	0 (0)
Respiratory disease (bacterial)	0.24 (22)	0.44 (41)	0.51 (47)	**0.71 (66)**	**0.65 (60)**
Respiratory disease (viral)	**0.43 (40)**	**0.75 (70)**	**0.78 (73)**	**0.86 (80)**	**0.71 (66)**

Top 2 levels of concern are shown in bold.

Table 6. Summary of motivations reported for using vaccines in 93 cow-calf herds.

	% of producers who agree with the statement (number)
I use vaccines to prevent disease because I have had a problem in the past and want to prevent it from happening again	
• Respiratory disease (pneumonia)	**0.60 (56)**
• Calf diarrhea (scours)	0.44 (41)
• Reproductive disease	0.19 (18)
I use vaccines to prevent disease because I have not had any problems with disease and am trying to prevent it from entering my herd	
• Reproductive disease	**0.80 (74)**
• Respiratory disease (pneumonia)	0.43 (40)
• Calf diarrhea (scours)	0.26 (24)

Top disease category which motivated use of vaccine is shown in bold.

Table 7. Factors typically considered in deciding what vaccines were used in each beef herd.

	% of herds (number) ranking each factor in top 3 reasons for using a vaccine
Vaccine cost	0.13 (12)
Need to mix vaccine before use	0.04 (4)
Modified live or killed/inactivated	0.25 (23)
Potential reactions or side effects	0.11 (10)
Potential to minimize treatment rate and AMU	**0.43 (40)**
Need to boost the vaccine	0.17 (16)
Time of year vaccine needs to be administered	0.26 (24)
Route of administration	0.14 (13)
Importance of the disease in herd	**0.72 (67)**
Economic benefits of using the vaccine	**0.70 (65)**

Top factors, which were considered in making the decision, are shown in bold.

Table 8. Summary of important sources of information about vaccines as reported for 93 cow-calf herds.

	% of herds (number) ranking each provider in top 3 information sources
Feed or drug company representatives	0.23 (21)
Friends and neighbors	**0.27 (25)**
Government publications	0.10 (9)
Nutritionists	0.08 (7)
Producer publications	**0.25 (23)**
Scientific journals	0.08 (7)
Social media	0.05 (5)
Veterinarian	**0.98 (91)**
Websites	0.13 (12)

The top 3 sources of information are shown in bold.

used IN vaccines for *Mannheimia* and *Pasteurella* either alone or in addition to the viral vaccine. Intranasal MLV vaccines for respiratory diseases can be used shortly after birth; however, the recommended second dose was only provided in 2 herds in the present study.

As well as highlighting the potential to further increase the vaccination of calves in the first few months after birth, several other opportunities were identified to enhance the use of vaccines. Only 3 out of 4 producers vaccinated their bulls for any diseases during 2016. Less than half of producers vaccinated their cows for clostridial diseases in 2016 and only 1 in 3 producers used clostridial vaccines in their bulls during this period. It is possible that more producers vaccinated their cows and bulls, but only every second or third year. Information on frequency was not captured in the present study if it was less than once a year. There are no established evidence-based recommendations on the frequency of revaccination for clostridial vaccines in adult animals. However, while this has not been studied specifically for clostridial vaccines, vaccination of the cow before calving should enhance colostral antibodies available to the calf (18). We previously reported an association between clostridial vaccine use in cows before the start of the calving season and a decreased risk of treatments for calf diarrhea (14).

Calf diarrhea was the third most common target of vaccination in cows and was the second most common reason for AMU in calves. However, only half of producers used vaccines for prevention of calf diarrhea. Although vaccines are considered to be an important tool, there are very few studies looking at the effectiveness of vaccines for calf diarrhea under field conditions, particularly for viral vaccines (21). As well, many producers may rely on environmental management schemes such as separate wintering and calving areas to reduce the risk of calf scours. Two large observational studies from western Canada did not find an association between scour vaccine use in cows and heifers and the frequency of treatment for calf diarrhea or calf mortality (11,14). Oral vaccines given to calves at birth were only reported by a small percentage of participants.

Lameness was the most common reason for AMU in bulls and cows (2), but the foot rot vaccine was rarely used in cows and only used by half of the herds in bulls. Most producers did boost the foot rot vaccine in accordance with label instructions. A previous randomized trial at the University of Saskatchewan found a significant reduction in the occurrence of foot rot in feedlot animals on a forage-based diet (22); however, the cost-effectiveness of foot rot vaccines is unknown when applied to bulls and cows on pasture.

Eye infections were another common reason for AMU in bulls and cows; however, pinkeye vaccine use was very infrequent. The limited use of the pinkeye vaccine was not surprising given the importance placed on the effectiveness of the product and the highly variable results from reported trials (23). In a recent review only 1 in 5 trials using randomization and blinding reported a beneficial effect of vaccination for pinkeye (23).

This study, like all survey-based research, has the potential for recall bias. However, the questionnaire was set up to help prompt memory and encourage reference to existing records and sales receipts by guiding the participants through the important disease groups for each class of cattle and through each stage of the production cycle. Study participants were provided with booklets with color pictures and descriptions to encourage reference to specific commercial products. In contrast to many other surveys, including the NAHMS questionnaire, we asked producers to provide the commercial names and did not expect them to remember or report which antigens were contained in the product. We translated the product name to the disease components using licensing information to minimize the potential for errors.

The study can also be criticized as not being a random sample. The study reflects cow-calf clients from veterinary practices in western Canada. As such, these cow-calf producers are more likely to have herd vaccination protocols compared with producers who do not have a strong relationship with their local veterinarian. The comparisons we report to previous studies are appropriate as the herds described in the previous studies were recruited using a very similar approach to what was used in the present study (10–14). However, these results may not apply to herds that do not have a strong veterinary-client-patient relationship, smaller herds, and herds from eastern Canada.

In summary, while there have been some improvements in vaccine uptake since previous surveys there are many other opportunities to increase the role of vaccines in infection prevention and control. This should be a priority, particularly for diseases frequently associated with antimicrobial use and where there is evidence the vaccine is effective. For example, the use of respiratory vaccines in calves before weaning has improved since 2001, but overall rates have not changed since 2010. However, the use of IN vaccines in calves before summer pasture turnout has increased since 2010 but was still not common practice at the time of this survey. Almost one half of producers are not vaccinating their bulls for IBR and BVDV, and 1 in 10 are not vaccinating their cows for these 2 important viruses. In most commercial cow-calf operations, bulls are purchased and may have an unknown vaccination status. There is also evidence that bulls infected with BVDV can potentially harbor longer term persistent infections within testicular tissue (24). It would seem prudent to advise all producers to ensure their bulls are also vaccinated annually along with the cow herd. While AMU for calf diarrhea and foot rot is common, the use of vaccines for these diseases is much less frequent. This might be explained in part because there is relatively limited scientific evidence on the cost-effectiveness of the calf scours and foot rot vaccines. CVJ

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